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Analysis of Clinical Discussions Based on Argumentation Schemes

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Abstract

Clinical discussions usually taking place in healthcare structures allow medical specialists to focus on critical cases, debate about different diagnostic hypotheses, identify therapeutic protocols, or choose among alternative treatments. This paper presents an argumentation-based approach to the analysis of clinical discussions, with the aim of providing a multidisciplinary medical team with a support tool that may help discover whether clinical discussions are affected by any weak points, such as contradicting conclusions, invalid reasoning steps, hidden assumptions, or missing evidences. To this end, we have adopted an approach based on argumentation schemes, which provide an intuitive yet well structured representation of general reasoning patterns. Argumentation schemes include one or more premises, a conclusion, and a set of critical questions that challenge the validity of the relation between premises and conclusion. We exploit argumentation schemes to interpret the assertions made by the participants in a meeting and to generate a graph of arguments connected through edges that represent support or attack relations existing among them. The resulting graph is then used to carry out a logical analysis of the discussion, highlighting, for instance, conflicting opinions or suggesting the need for gathering additional information. To show the potential of our approach, we have developed a sample case based on a clinical discussion taken from literature. After having identified a set of argumentation schemes appropriate for the medical domain considered, the case has been analyzed and a detailed logical analysis has been carried out.

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Keywords: Clinical discussion; argumentation; argumentation schemes; intelligent support system.

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1. Introduction

Multidisciplinary clinical discussions are becoming a routine activity in hospitals and healthcare structures in general. A clinical discussion is understood here as a sequence of sessions – or meetings – taking place in a strict temporal order. Clinical discussions provide the forum for specialists of various medical disciplines to focus on critical cases, debate about the diagnostic hypotheses, therapeutic protocols or follow-up of patient conditions, and to devise the most appropriate treatment. The purpose of clinical discussions is to support shared decision making, in order to ensure the highest standard in effectiveness and efficiency. Each participant brings his/her own perspective, thus contributing to reach a more informed and definitely better decision and overcoming the limitations of individual medical practices[1].

However, as witnessed by many physicians we have interviewed, such discussions are never documented[2,3], neither on paper nor through recording tools; only the final decisions that determine the specific actions to perform - such as further examinations, surgical operations, or therapeutic treatments - are reported in medical records. On the other hand, storing the main steps that lead to a decision and the reasons underlying the decision made could provide a great advantage. For example, recording a whole discussion might help avoid that decisions in conflict with those proposed in a former sessions are made, or that the same reasoning paths are explored twice, or that some important issues raised in a meeting are later neglected. Indeed, alternative diagnostic hypotheses or treatments that have been discarded during a session may be resumed in a new meeting, when new information about the patient or about the effectiveness of a drug is acquired. The importance of having appropriate, complete and up-to-date information about all previous sessions available at a meeting is underlined by Groth et al.[4]. Frykholm and Groth[5] describe how physicians often rely on their own memory, even though they may not always remember all the details.

This issue is currently becoming important also for legal reasons. For example, a deviation from a therapeutic protocol may have been decided because of particular patient conditions, such as age or allergies. However, if this information is not carefully documented in the medical record, it may happen that, in case of therapy failure, legal issues are raised against the participants in the decision and the relevant healthcare structure. A clear documentation of the reasoning path that brought to the final decision, starting from the analysis of symptoms, patient data, examination results, and therapy effects, might contribute to shed light on the physicians' behavior and demonstrate its accurateness.

For the reasons reported above, a system that can help physicians carry on effective medical discussions would certainly be welcome. A **clinical discussion support system** should focus on two main objectives:

1) *Documentation*. It is fundamental to record and document a clinical discussion in an informal yet well structured way. The representation language adopted should account for the logical and temporal structure of a discussion, but at the same time, it should be easily understandable by physicians. Discussion documentation will serve as a memory support for the following meetings and as a justification record for the decisions made.
2) *Logical analysis*. Once a discussion has been properly documented, it can then be interpreted from a logical point of view, on the basis of a set of reasoning patterns that are considered valid in the specific medical domain. This analysis should be able to highlight contradicting opinions, to recognize invalid reasoning steps, to discover hidden assumptions, or to identify missing evidences. Logical analysis is fundamental to support a more correct and sound evolution of physicians' reasoning through the sequence of meetings that constitute a clinical discussion.

As far as the objective of documentation, considering that it is not completely disjoint from the objective of logical analysis, we have proposed a novel approach to the documentation of clinical discussions[6,7], inspired to graphical notations proposed in the frame of argumentation theory[8]. An argumentation system proposes a defeasible reasoning paradigm where arguments are incrementally posted by the agents participating in a discussion and are assessed on the basis of the attack or support relations existing among them. An argument is a structured entity that includes a conclusion and a set of premises that represent the (not necessarily deductive) reasons to believe the conclusion[8]. Several approaches to the visualization of argumentation systems are reported in the literature. For instance, Van Gelder[9] proposes the argument map notation, a "box and arrows" diagram in which nodes correspond to claims and links indicate their evidential relationships. In the approach of Cyra and Gorski[10] an argument structure is represented as a left-to-right hierarchy (similar to file directories), which allows for effective representing,

traversing, and managing large collections of arguments. Other well-known systems in this research area – like ArgVIS[11], Araucaria[12], Rationale[13], SEAS[14], and Carneades[15] – also provide specific diagrammatic representations of arguments; however, most of them require that the user is familiar with argumentation concepts, such as "premise", "conclusion", "counterargument", "support", "attack", and that he/she is familiar with formal reasoning systems. Our approach[6,7] aims at providing a disciplined yet well structured representation of the discussion carried out in a clinical meeting, thus ensuring simplicity and usability. It has been designed by carefully taking into account the specific background and the needs of physicians; moreover, it exploits an elementary domain ontology to represent different medical concepts that physicians use during a discussion, such as symptom, sign, examination result, diagnosis, and treatment. Each session of a discussion is organized as a tree diagram, where nodes represent physicians' statements and arcs between pair of nodes denote a logical relation of attack or support between them. In particular, when a statement is asserted by a physician, a new node is created and "pro" or "con" arcs are directed from it to each relevant node representing a previously asserted statement that the new assertion supports or attacks. The resulting tree diagram provides therefore a useful graphical support to record the assertions made during a meeting and to recall the temporal and logical relations among them. In our approach it is assumed that documentation is produced by a physician taking part to the clinical meeting; thus it is shared by all participants who can contribute to its refinement and validation. This way, no discussion information is lost and each participant will be able to resume and understand the documentation in later discussion sessions.

As far as the objective of logical analysis, it is the specific topic of this paper. After a discussion session has been concluded and properly documented, it should be interpreted from a logical point of view, in order to test the validity and robustness of the reasoning paths followed during the meeting and of the conclusions reached. Logical analysis is, therefore, a post-processing activity, that is carried out between the end of a meeting and the beginning of the next one, and which is aimed at providing useful inputs to the physicians to support and stimulate the following discussion session. To this purpose we have adopted an approach based on argumentation schemes[16]. An argumentation scheme is a structured textual representation of a reasoning pattern that includes one or more premises, a conclusion, and some critical questions that may be used to challenge the validity of the relation between the premises and the conclusion. In order to identify the most basic and usual argumentation schemes in the medical field, a variety of literature case studies have been analysed; among others, the works of Chang et al.[17] in the field of medical oncology, the CARREL system[18] on transplants, and the study of Frykholm and Groth[5] about diseases in the upper abdomen. After having defined a suitable set of argumentation schemes for the medical domain, we have designed a method to apply them to a discussion session in order to carry out a thorough logical analysis. As a result, new evidence and hints useful to support the next meeting are derived.

In order to introduce our approach and show its validity this paper focuses on the discussion example presented by Chang et al.[17], and illustrates how a clinical meeting can be analysed through argumentation schemes. In particular, the paper is organized as follows: Section 2 describes the structure of multidisciplinary clinical discussion and introduces the sample clinical discussion that we will use to show our approach; Section 3 presents a selection of the argumentation schemes that have been identified for the medical domain; Section 4 shows how the sample discussion can be analysed and illustrates the results obtained; finally, Section 5 concludes the paper and outlines future research issues.

2. Multidisciplinary Clinical Discussions

A **clinical discussion** is constituted by a set of **sessions** (or **meetings**), taking place in a strict temporal sequence. Each session is based on a set of facts shared by all participants (for example, the general state of the patient, the results of clinical tests, the effects of the on-going treatment, etc.[5]) and includes all the statements asserted by the participants, expressing their personal opinions.

Each session evolves in general through three stages:

1. The session begins with the medical staff introducing the patient and providing detailed information about present and earlier diseases, subjective symptoms, and general health status. Objective observations and results of clinical tests are also reported. Such general facts and observations are assumed to be shared by all participants and are not disputable.

2. After the presentation, the participants in the meeting assert their proposals about possible diagnosis or treatment and support them through their own experience, literature cases, or clinical guidelines. During the session, participants may attack the assertions posted by colleagues or may support them.
3. At the end, participants identify a set of acceptable conclusions and then decide for one of them.

In particularly critical cases such as a difficult diagnosis, a rare pathology or a new treatment, several meetings are necessary before a valid and shared conclusion is reached, thus giving rise to an articulated clinical discussion.

To illustrate our approach, we focus on a literature example concerning a larynx cancer case[17]. The case involves different medical specialists, namely Surgeons (S) and Radiation Oncologists (RT), and deals with the best treatment to apply for a patient with early stage superficial unilateral larynx cancer. Fig. 1 shows the transcript of the discussion session reported by Chang et al.[17].

S1	(A1) My opinion is to take out the patient's larynx. This is has the best cure rate of 99%.
S2	(A2) I agree, taking out the patient's larynx would provide the best cure potential.
S3	(A3) I also agree, taking out the patient's larynx would provide the best cure potential.
RT1	(A4) But if you take out the patient's larynx, the patient will have no voice.
RT1	(A5) However, if you use radiotherapy, there is a 97% cure rate from the radiotherapy and about 97% voice quality, which is very good. The 3% who fail radiotherapy can have their larynx removed and most of these will be cured too.
S2	(A6) My opinion is also that the patient should have a hemi-laryngectomy. This will give a cure rate is as good as radiation therapy.
S3	(A7) I agree, performing a hemi-laryngectomy would give a cure rate as good as radiotherapy.
RT1	(A8) Yes, I have performed many hemi-laryngectomies, and when I reviewed my case load, the cure rate was 97%, which is as good as that reported internationally for radiotherapy.
RT2	(A9) I agree, however, you fail to take into account the patient's age. Given the patient is over 75, operating on the patient is not advisable as the patient may not recover from an operation.
RT1	(A10) Yes, however, in this case, the patient's performance status is extremely good, the patient will most likely recover from an operation. (i.e. the general rule does not apply)
S2	(A11) Reviewing our past case decisions, evidence suggest that the we have always performed a hemi-laryngectomy, hence my preference is to do the same.
S3	(A12) I agree, however, there is some new medical literature reporting that the voice quality after a hemi-laryngectomy was only 50% acceptable and the reporting institution was the North American leaders in hemi-laryngectomy, hence we should perform radiotherapy.

Fig. 1. The larynx cancer case.

3. Argumentation Schemes for the Medical Domain

Argumentation schemes, according to Walton's definition[16], represent common types of reasoning patterns in a specific subject domain in the form of premise-conclusion. More precisely, each argumentation scheme has a name, a set of premises, a conclusion, and a set of critical questions. Critical questions are a way to let the user know about the possible weak points or exceptions of an argument, and give a way for others to attack it. Premises, conclusion, and critical questions may all involve parameters, that is variable terms that can be instantiated with values relevant to a specific case, to yield an argument. The semantics of an argumentation scheme is that if all the premises are believed, then there are good reasons to believe the conclusion as well, provided that there is no positive answer to any critical question, that is there is no evidence that the argument should not be believed (note that this does not mean that all critical questions have actually a negative answer). Thus, critical questions are indeed intended to challenge the validity of an argument and provide a sieve to make sure that the general reasoning pattern correctly applies to the specific case at hand.

Walton defined twenty-five argumentation schemes in the legal field. Inspired by this work, in the first phase of our research, a variety of literature case studies have been analysed, such as those reported by Frykholm and Groth[5], and Chang et al.[17], in order to identify the most frequent argumentation schemes in the medical field. A selection of the identified argumentation schemes is shown in Fig. 2; for the sake of simplicity, only a subset of critical questions have been reported. The only conceptual entities used in these sample argumentation schemes are: patient (P), disease (D), treatment (T), the characteristics of a treatment (C), which may include such attributes as the cure rate (R) and the side effects (E), a set of health conditions of a patient (N), physicians (PH), medical domains (DOM), and assertions (A).

1) Argument for Treatment Efficacy
ATE (P, D, T)
Premise 1: Patient < P> is affected by disease <D>.
Premise 2: Treatment <T> is able to cure disease <D>.
Conclusion: Treatment <T> should be brought about for patient <P>.
CQ1: Is there an alternative treatment better than <T>?
CQ2: Is there a risk for patient <P> in following treatment <T>?

2) Argument for Better Treatment
ABT (T1, T2, C1, C2, P)
Premise 1: Patient < P> is affected by disease <D>.
Premise 2: Treatment <T1> with characteristics <C1> is able to cure disease <D>.
Premise 3: Treatment <T2> with characteristics <C2> is able to cure disease <D>.
Premise 4: Characteristics <C2> are preferable w.r.t <C1>.
Conclusion: Treatment <T2> should be brought about for patient <P>.
CQ1: Is there an alternative treatment better than <T2>?
CQ2: Is there a risk for patient <P> in following <T2>?

3) Argument for Treatment Risk
ATR (P, T, N)
Premise 1: Patient <P> has conditions <N>.
Premise 2: Conditions <N> are a contraindication for treatment <T>.
Conclusion: Patient <P> should not follow treatment <T>.
CQ1: Does <P> have any specific condition that can limit the risk for <T> implied by conditions <N>?

4) Argument for Risk Containment
ARC (P, C1, C2, T)
Premise 1: Patient <P> has conditions <C2>.
Premise 2: Conditions <C2> limit the risk of treatment <T> . under conditions <C1>.
Conclusion: The risk for <P> in following treatment <T> is limited.

5) Argument for Preference from Side Effects
APSE (C1, C2, {E1, E2, …,En})
Premise 1: Characteristics <C1> include side effects <E1, E2, …,En> Premise 2: side effects <E1, E2, …,En> are not included in characteristic <C2> .
Conclusion: <C2> are preferable w.r.t <C1>.
CQ1: Are there other reasons to prefer <C1> w.r.t. <C2>?

6) Argument from Medical Expert Opinion
AMEO ({PH1, PH2, PH3, ... }, DOM, A)
Premise 1: Physicians <PH1, PH2, PH3, ...> are specialists in domain <DOM>.
Premise 2: Physicians <PH1, PH2, PH3, ...> assert <A>.
Conclusion: <A>.
CQ1: Is <A> inconsistent with other experts' assertions?
CQ2: Is <A> inconsistent with recent studies?
CQ3: Is there no evidence that substantiates assertion <A>?
CQ4: Is the assertion <A> not in domain <DOM>?

Fig. 2. A sample set of argumentation schemes for the medical domain.

In order to represent the complex reasoning activity that takes place in a session of a clinical discussion, argumentation schemes are used to interpret the assertions made by participants in the meeting. Given a significant piece of discussion (usually a single statement), the argumentation scheme that best fits the logical structure of the participant's reasoning path is selected and instantiated to yield an actual argument. The arguments proposed by the various participants are then connected ~~to~~ each other through edges that represent the fundamental logic~~al~~ relations of support or attack existing among them.

In particular, premises of an argument can be supported by other arguments or challenged by counterarguments. Thus, each premise can be related to those arguments that support it or that attack it. Similarly, critical questions of an argument can be related to those arguments that provide a positive answer to them, thus attacking the relevant argument. The result of this activity is a directed graph where nodes are arguments (i.e., instances of a specific argumentation scheme) and edges are of two kinds, namely support and attack. More specifically, an argument supporting a premise of another argument is connected to the latter by a support edge, while attack edges arise either when an argument provides a positive answer to a critical question or challenges a premise of another argument.

4. Discussion Analysis through Argumentation Schemes

In this section, we show how the larynx cancer case of Fig. 1 can be analyzed by means of the argumentation schemes for the medical domain introduced in the previous section.

Assertions A1, A2 and A3 can be modeled by two arguments. The first instantiates argumentation scheme ATE with parameters P=patient (where "patient" denotes a specific patient's name), D=larynx cancer, and T=laryngectomy. Accordingly, we obtain **Arg1=**ATE(patient, larynx cancer, laryngectomy).

The second argument supports Premise 2 of Arg1, and can be constructed using the argumentation scheme AMEO. In particular, <PH1>, <PH2> and <PH3> are the physicians S1, S2 and S3 and the assertion <A> can be instantiated by "Treatment T is able to cure disease D with cure rate 99%". This yields **Arg2**=AMEO({S1, S2, S3}, surgery, {laryngectomy is able to cure larynx cancer with cure rate 99%}), which is connected through a support edge to Arg1 (see Fig. 3).

Assertions A4 and A5 by RT1 provide an answer to critical question CQ1 of Arg1, by using argumentation scheme ABT. Parameters T1 and P are instantiated by laryngectomy and patient; by instantiating the remaining parameters with the information provided by A4 and A5, we get **Arg3**=ABT(laryngectomy, radiotherapy, {no-voice, cure-rate_99%}, {voice_quality_97%, cure-rate_97%, laryngectomy_still_possible}, patient). Now it is straightforward to recognize that Arg3 attacks Arg1, since it provides a positive answer to CQ1.

Other arguments can be derived from this first fragment of the discussion (assertions A1-A5). For example, Premise 3 of Arg3 can be supported by an argument based on medical expert opinion (AMEO) derived from RT1 expertise. Also, one might specify the reasons why the characteristics of radiotherapy are preferred w.r.t. those of laryngectomy, by supporting Premise 4 of Arg3 with **Arg4**=APSE({no-voice, cure-rate_99%}, {voice_quality_97%, cure-rate_97%, laryngectomy_still_possible}, no_voice).

Assertion A6 triggers in turn a counterargument to Arg3. This is obtained answering critical question CQ1 of Arg3 by instantiating argumentation scheme ABT again. Note that the reasons why hemy-laryngectomy should be preferred w.r.t radiotherapy are not stated explicitly in the discussion: S2 only states that hemy-laryngectomy gives a cure rate as good as radiotherapy, hiding an implicit reasoning. To correctly instantiate the ABT argumentation scheme, such reasoning must be clarified, i.e. C1 must be assigned {radiation_exposure, cure-rate_97%} and C2 {cure-rate_97%}, thus obtaining **Arg5**=ABT(radiotherapy, hemy-laryngectomy, {radiation_exposure, cure-rate_97%}, {cure-rate_97%}, patient). The premises of Arg5 can again be supported by different arguments. In particular, Premise 3 of Arg5 can be supported by an argument based on AMEO (through assertions A6, A7, A8), while Premise 4 by an argument instantiating APSE (based on the fact radiation exposure is a side effect of radiotherapy not shared with hemy-laryngectomy).

Assertion A9 provides a positive answer to critical question CQ2 of Arg5 triggering **Arg6**=ATR(patient, hemy-laryngectomy, {age_over_75}). Thus, Arg6 attacks Arg5 as shown in Fig. 3.

Assertion A10 provides a positive answer to critical question CQ1 of Arg6, triggering **Arg7**= ARC(patient, {old_age}, {extremely_good_status}, hemy-laryngectomy), thus attacking Arg6.

Turning to assertion A11, it is not clear whether it supports Arg5, that is it corroborates the high cure rate of hemy-laryngectomy, or it supports Arg7, that is it confirms that old patients in good health conditions most likely recover from operation. Thus, the logical analysis has brought to light an ambiguous or at least unclear assertion that should be clarified in the following meeting by medical specialist S2.

Finally, assertion A12 provides a positive answer to critical question CQ1 of Arg5 through the argument **Arg8**=ABT(hemy-laryngectomy, radiotherapy, {voice_quality_50%}, {voice_quality_97%}, patient). Premise 2 related to the voice quality of hemy-laryngectomy can then be supported by instantiating an argumentation scheme based on medical literature (not shown in Fig. 3), based on assertion A12.

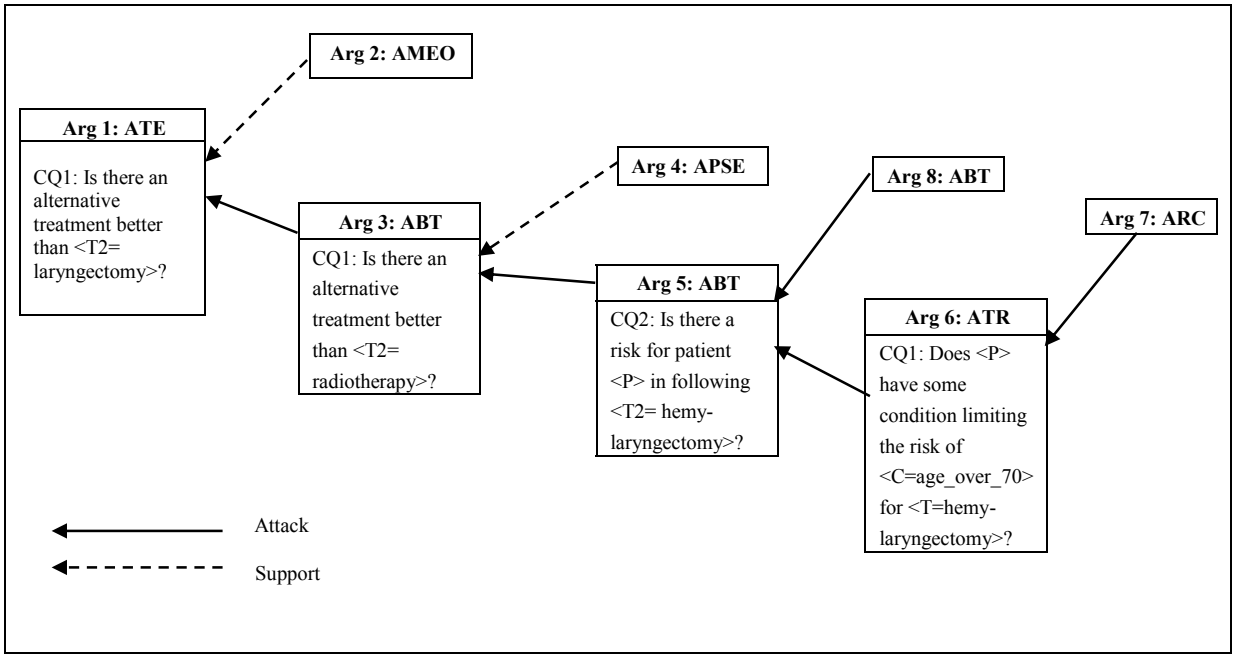

Fig. 3. The (partial) argumentation graph representing the discussion session reported in Fig. 1.

The resulting graph in Fig. 3 can be processed by a standard conflict resolution algorithm to determine the set of arguments (corresponding to physicians' assertions) that, according to a specific argumentation semantics[19], can be considered as justified. In this case, according to the most usual semantics[19], it turns out that arguments Arg2, Arg3, Arg4, Arg7, Arg8 are justified. According to the relevant conclusions (in particular, those of Arg3 and Arg8), radiotherapy should be brought about among the considered treatments.

It is interesting to note that, if assertion A12 were discarded (that is Arg8 removed), both Arg1 and Arg5, supporting laryngectomy and hemy-laryngectomy respectively, would be justified thus yielding two alternative (contradicting) conclusions. This conclusion might be presented to the physicians at the beginning of the following meeting, thus stimulating further investigation and discussion. Physicians will be required to explicitly compare the alternative treatments, by providing further arguments to rationally decide among them.

5. Conclusions

In this paper, we have presented an original approach to the logical analysis of clinical discussions based on argumentation schemes. We are currently developing an interactive system able to support a domain expert, specifically trained in practical argumentation, to go through the discussion diagram described in Fogli et al.[6] and Al Qassas et al.[7] and progressively construct an argumentation graph through the selection and instantiation of suitable argumentation schemes. A domain expert might be a junior doctor in training, who usually plays similar roles in multidisciplinary medical team meetings, as observed in the study of Kane et al.[3].

At the end of the logical analysis, the system will provide the participants to the discussion with different kinds of information: a) suggestions for decision making, in the case only one argument related to a specific treatment or diagnosis is justified; b) warnings about possible alternative conclusions, in the case where several arguments associated to alternative treatments or diagnoses are justified; c) suggestions for exploring the critical questions that have not been assigned an answer, in order to make hidden assumptions explicit or to gather additional information about the case under discussion.

Additionally, future work will be focused on the validation of the identified argumentation schemes with physicians, and on the definition of new argumentation schemes from other discussions, for example argumentation

schemes that consider the side effects of treatments on the basis of specific medical literature or clinical trials. Furthermore, the possible use of domain ontology to support logical analysis will be explored as well.

Finally, the study of the impact of the system on work organization will be investigated. In particular, the socio-technical issues highlighted in Zhou et al.[20] will be addressed, as well as the practical feasibility of discussion documentation and logical analysis.

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